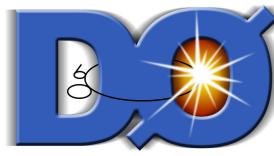


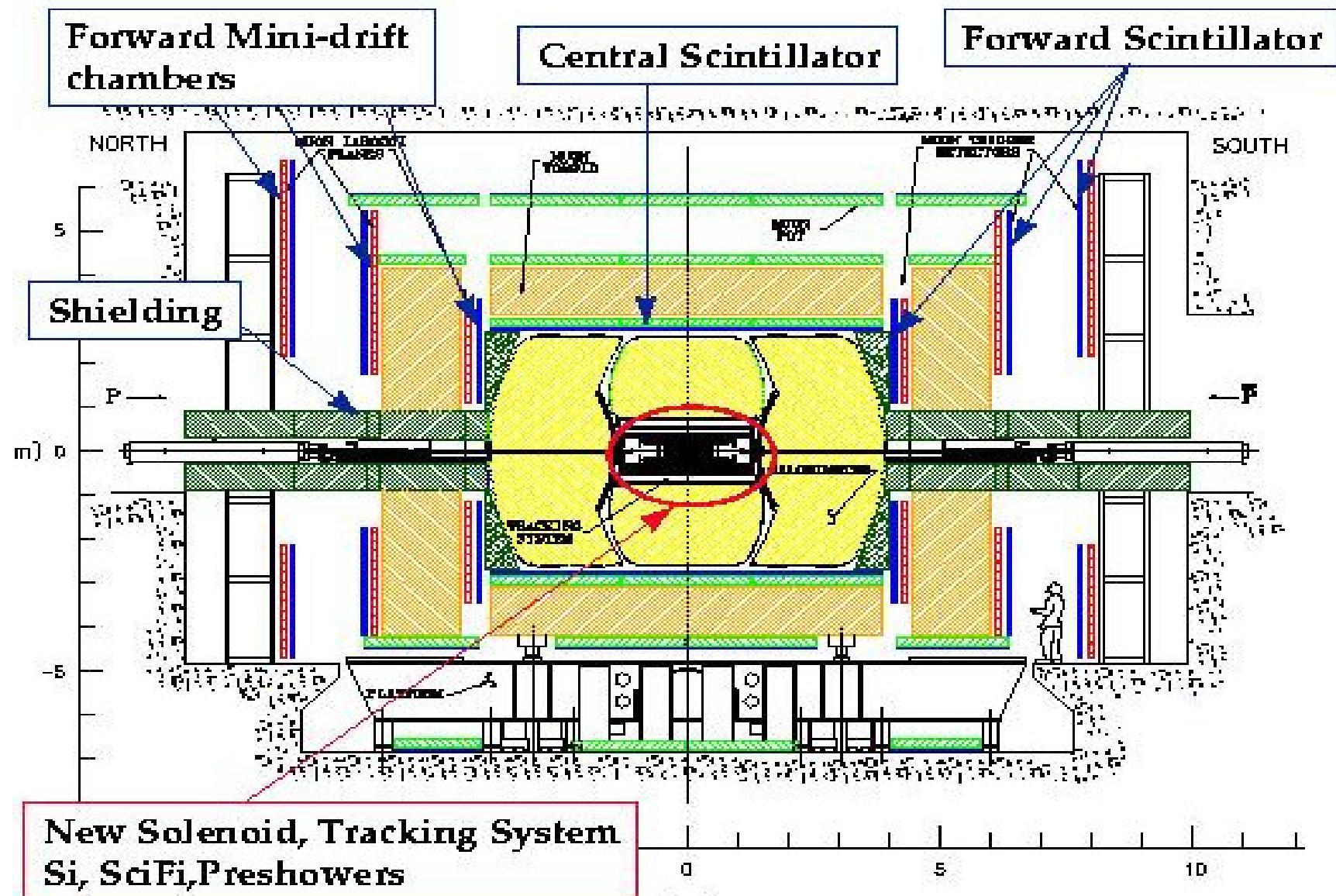


Heavy Flavor Physics at DØ

Alberto Sánchez Hernández
CINVESTAV (Mexico City)
DØ Collaboration



DØ Detector

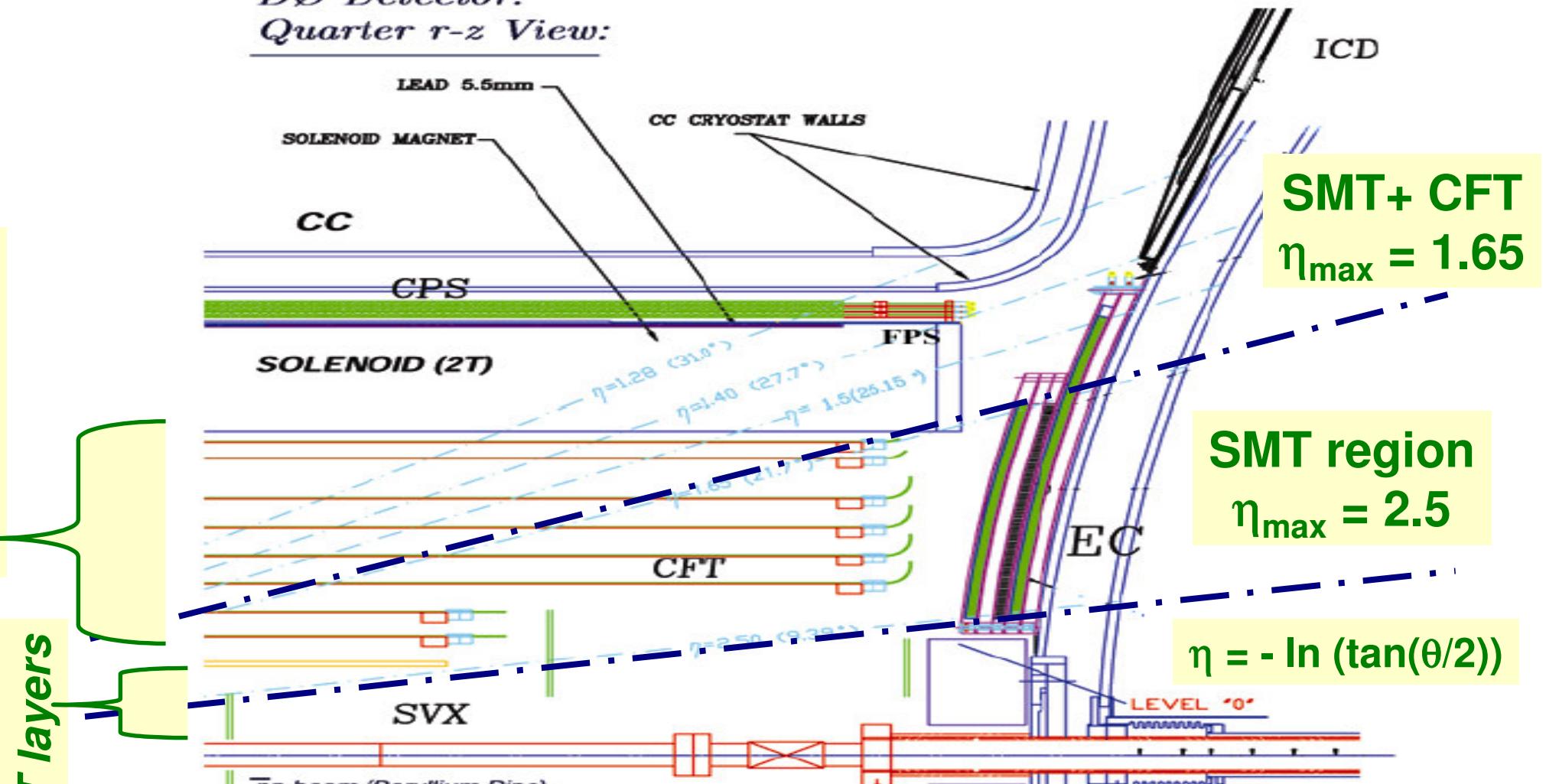




Tracker

DØ Detector:
Quarter r-z View:

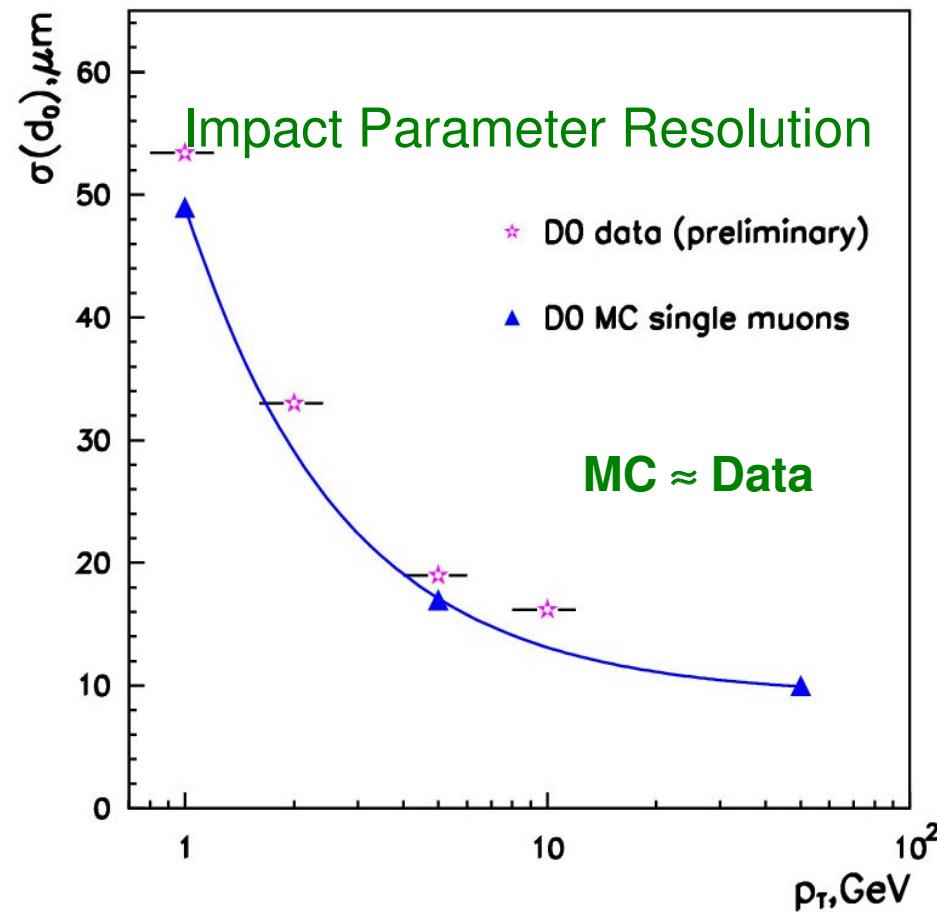
8x2 CFT layers



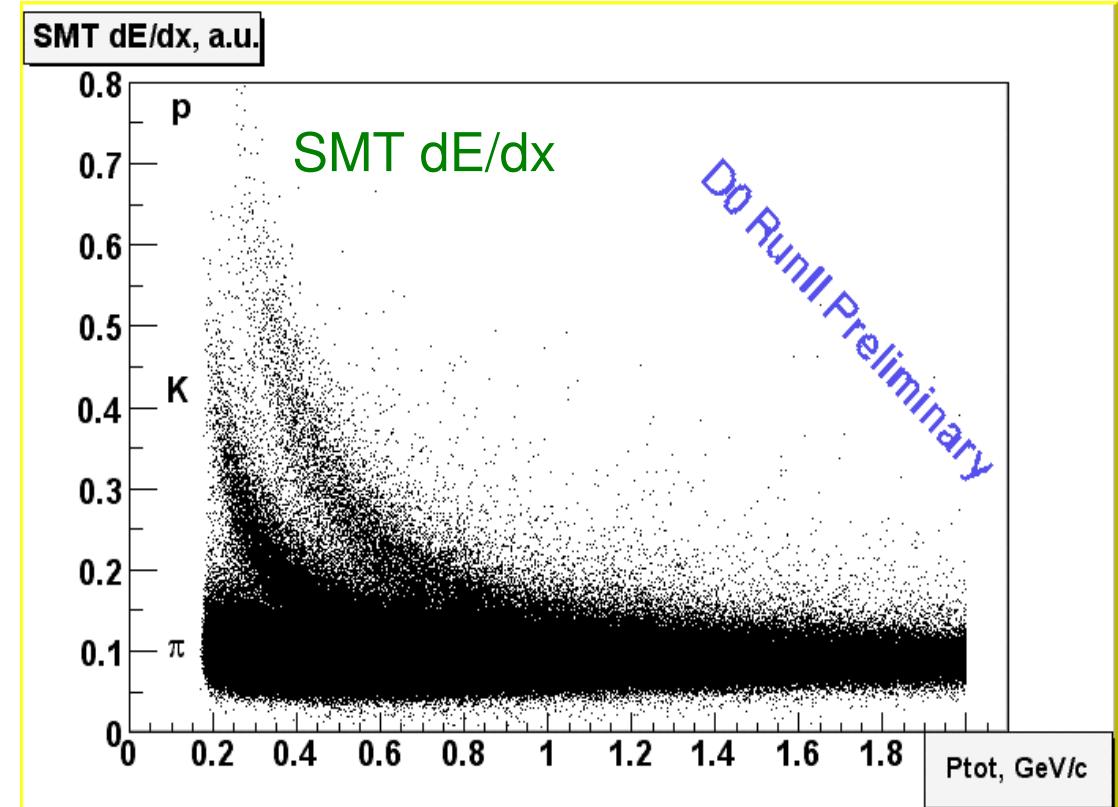
Trigger: muon+track covers $|\eta| < 2.2$



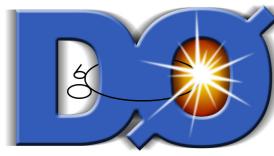
Tracking Performance



$\sigma(\text{DCA}) \approx 53 \mu\text{m} @ P_t = 1 \text{ GeV}$
and $\approx 15 \mu\text{m} @ \text{higher } P_t$



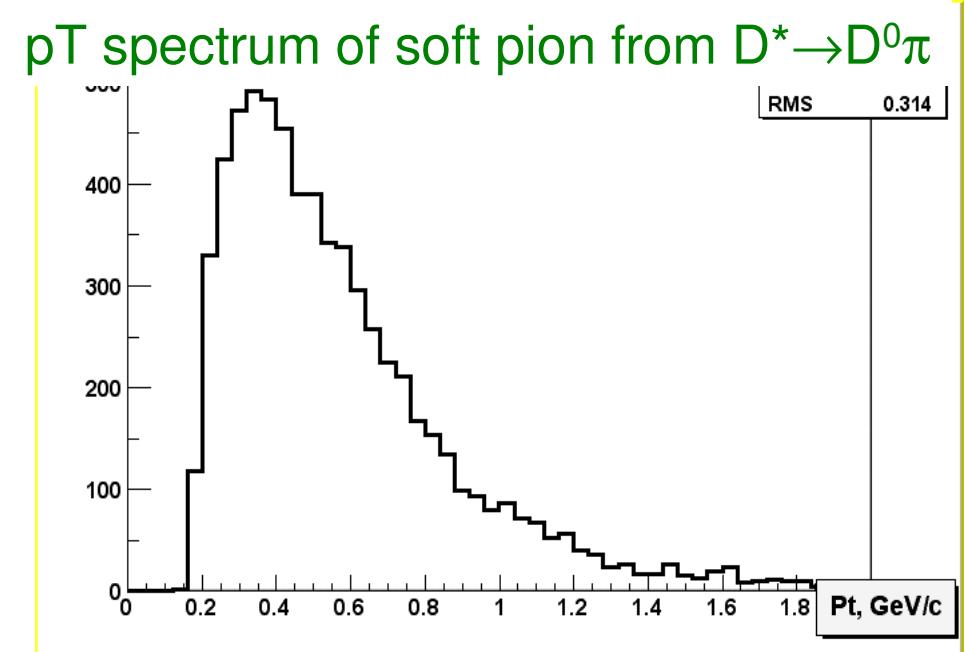
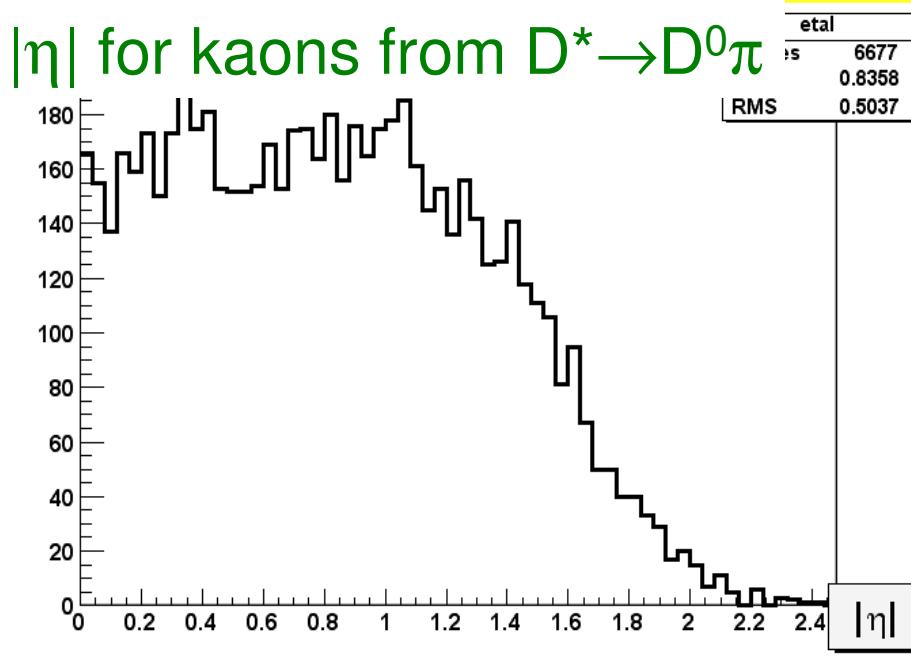
Can provide
K/ π separation for $P_{\text{tot}} < 400 \text{ MeV}$
p/ π separation for $P_{\text{tot}} < 700 \text{ MeV}$
NOT yet used for PID



Tracking Performance



Data from semileptonic decays ($B \rightarrow \mu D X$)



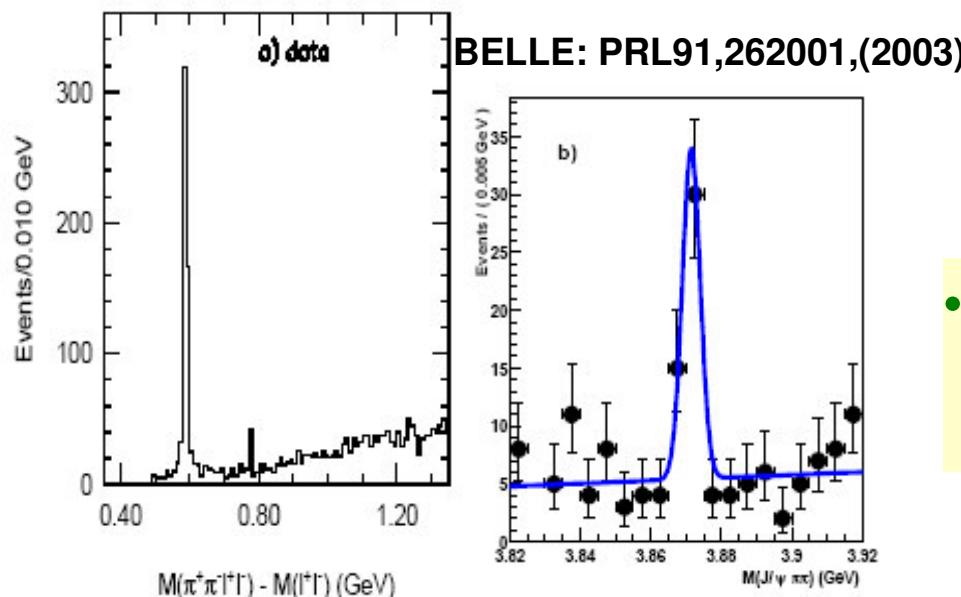
Tracks are reconstructed

- over a wide η range
- starting from $p_T = 180 \text{ MeV}$

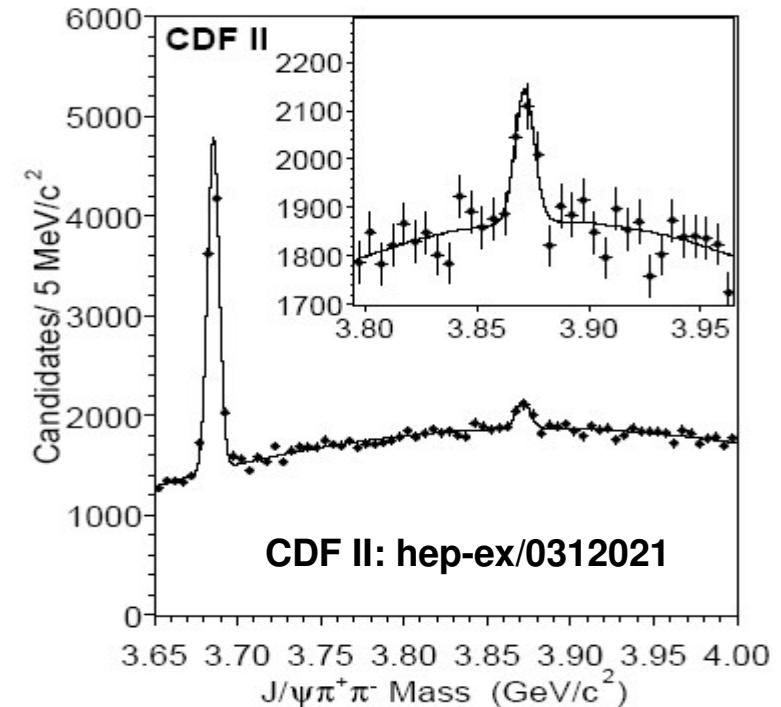
Efficient muon and tracking system give us a large sample of semileptonic B decays

A New Particle: X(3872)

- Last Summer BELLE announced a NEW particle around $3872 \text{ MeV}/c^2$ when looking at $B \rightarrow K^+ X$ ($X \rightarrow J/\psi \pi^+ \pi^-$)
- possible charmonium state or an exotic meson molecule (?)
- BELLE didn't find evidence for $\gamma \chi_{c1}$



Alberto Sánchez-Hernández (CINVESTAV)



- $X(3872) \rightarrow J/\psi \pi^+ \pi^-$ production in ppbar collisions has been confirmed by CDF

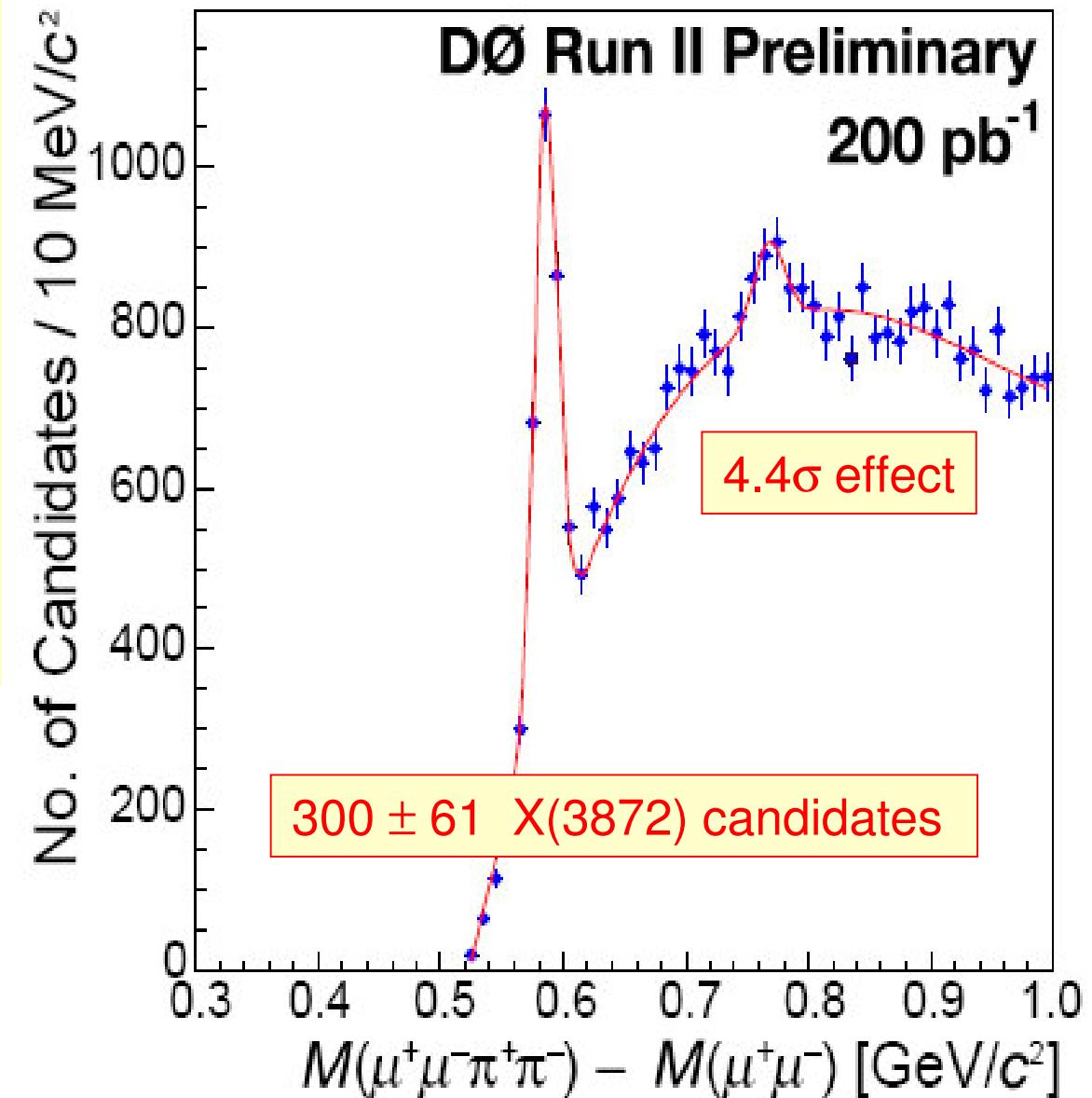
Aspen Winter Conference, February 1-7, 2004



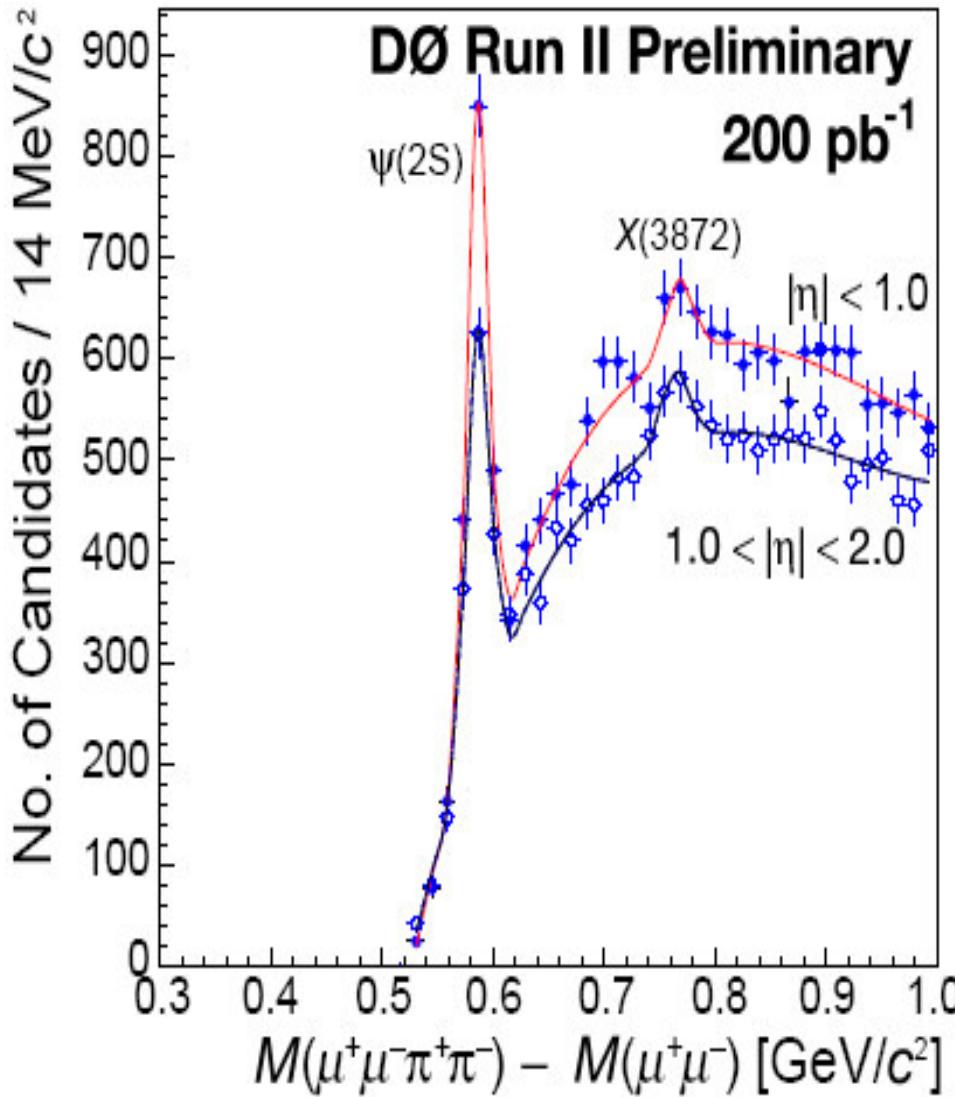
What can we say about the X(3872)?

- Using 200 pb^{-1} of DATA collected April 2002 – September 2003, we look for $X(3872) \rightarrow J/\psi \pi^+ \pi^-$
 - SMT hit > 1
 - num tracks < 100
 - $pT(J/\psi) > 4 \text{ GeV}/c$
 - $2.8 < M(\mu^+ \mu^-) < 3.4 \text{ GeV}/c^2$
 - $pT(\pi) > 0.4 \text{ GeV}/c$
 - π 's within same cone as J/ψ
 - $M(\pi^+ \pi^-) > 0.52 \text{ GeV}/c^2$
 - $M(\mu^+ \mu^- \pi^+ \pi^-) - M(\mu^+ \mu^-) < 1.0 \text{ GeV}/c^2$
 - $\chi^2(\mu^+ \mu^- \pi^+ \pi^- - \text{vertex}) < 16$
 - $|z_{\text{vertex}}| < 35 \text{ cm}$

$$\Delta M = 0.7684 \pm 0.0035 \text{ (stat)} \pm 0.0039 \text{ (sys) } \text{GeV}/c^2$$

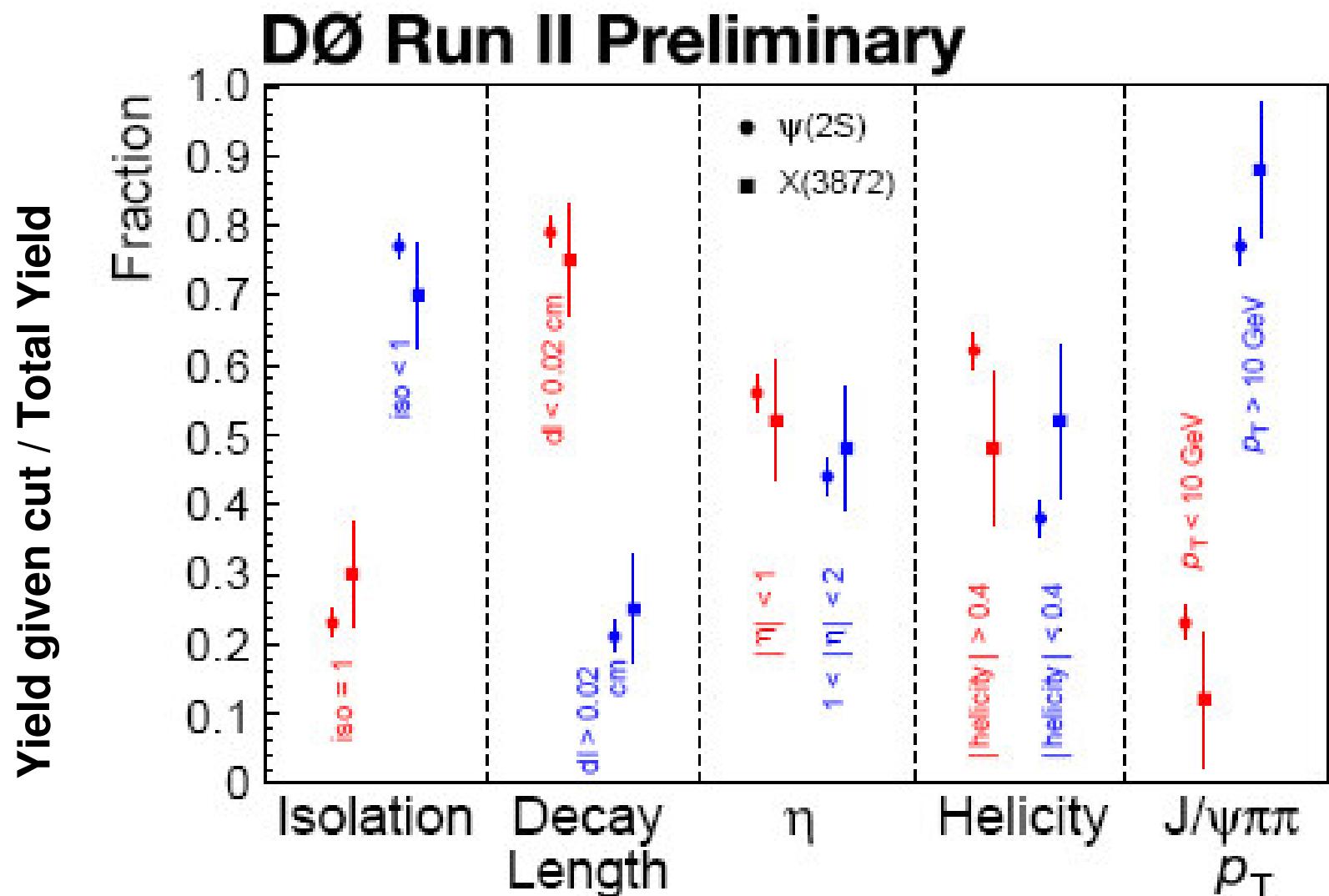


Properties of X(3872)



- Look if production characteristics are similar to $\psi(2S)$.
- Data was binned for different variables: decay-length, isolation, η (pseudorapidity) pT, and helicity of $(\pi^+\pi^-)$

X(3872) - $\psi(2S)$ comparison

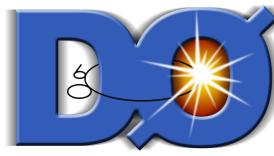


Within the current statistical uncertainties, the production of $X(3872)$ has similar behavior as the $cc(\bar{c}\bar{s})$ state $\psi(2S)$



What is X(3872)?

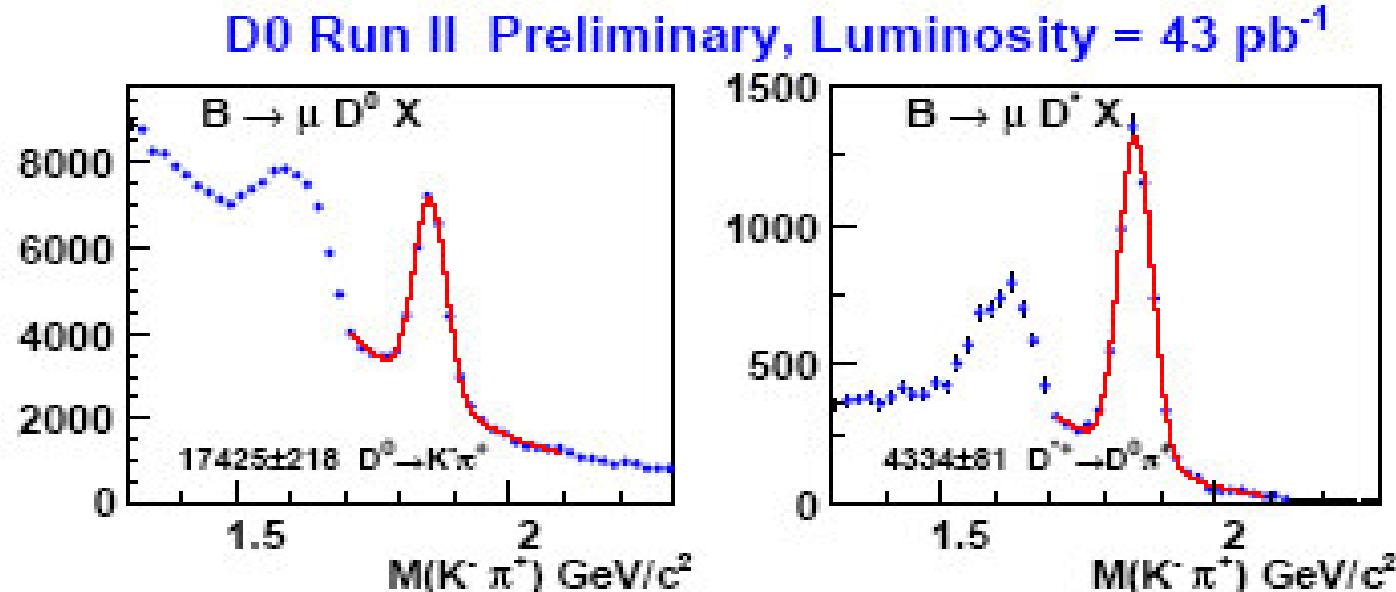
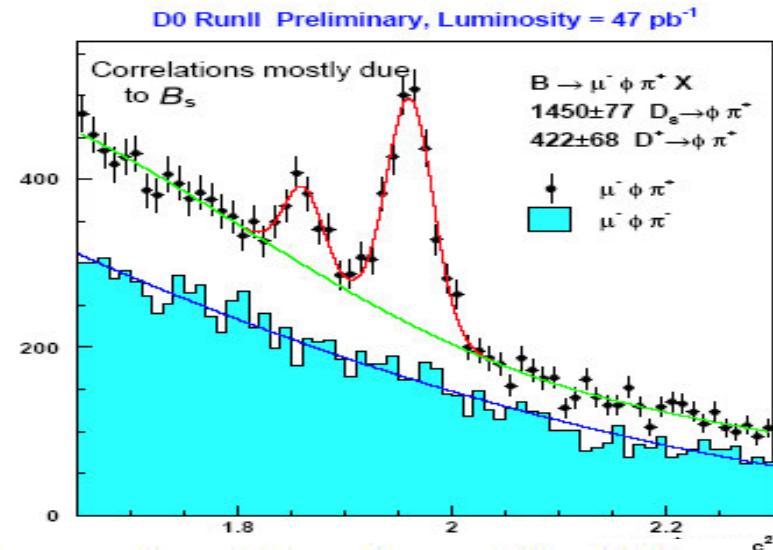
- If the charged analog $X^+ \rightarrow J/\psi \pi^+ \pi^0$ was observed, then cc(bar) hypothesis could be ruled out
- While observing radiative decays $X \rightarrow \gamma \chi_{c1}$ would favor cc(bar) hypothesis
- Both of these would require DØ to identify low energy π^0 and γ (work in progress)
- Our tests show: production characteristics of X(3872) (in the used variables) seems similar to those from $\psi(2S)$ (within the statistical uncertainties), this would tend to favor a cc(bar) hypothesis, but we do not know (yet) how these characteristics look for an exotic meson-molecule (theoretical input needed).

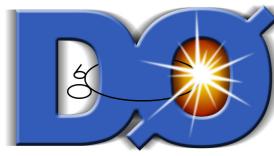


B Semileptonic Samples

- Muon:
 - $P_T > 2 \text{ GeV}/c$
 - $n\text{SMT} > 1$
 - $n\text{CFT} > 1$
- Charged tracks:
 - $pT > 0.7\text{-}1 \text{ GeV}/c$
- Secondary Vertex
 - $L_{xy} / \sigma_L > 4$
 - $\cos(\theta(L, P_D)) > 0.95$

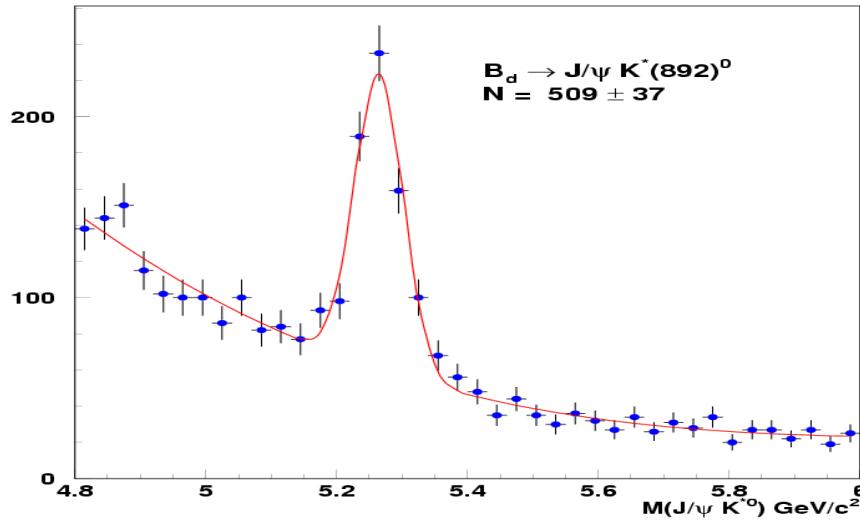
For Mixing and Lifetime studies



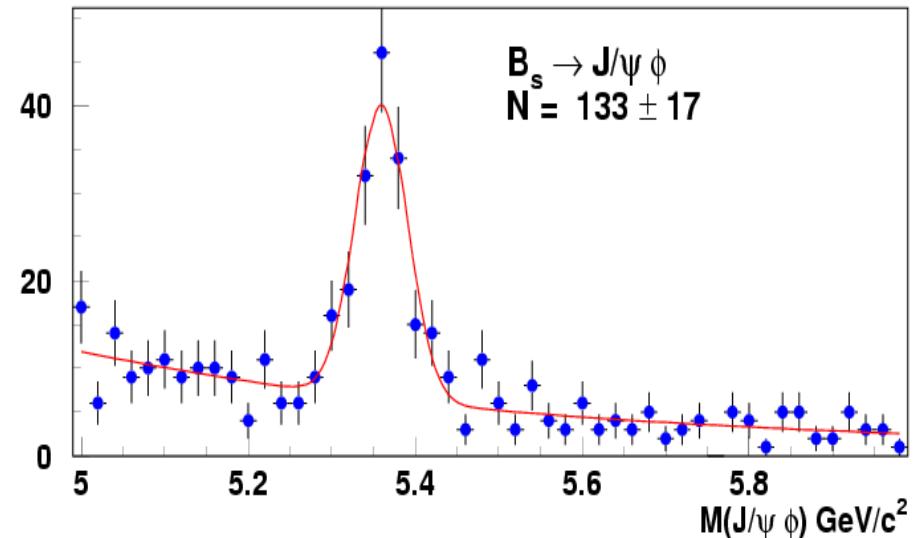


B_{d,s} Masses (J/ψ + K^{0*}, ϕ, K⁰_s)

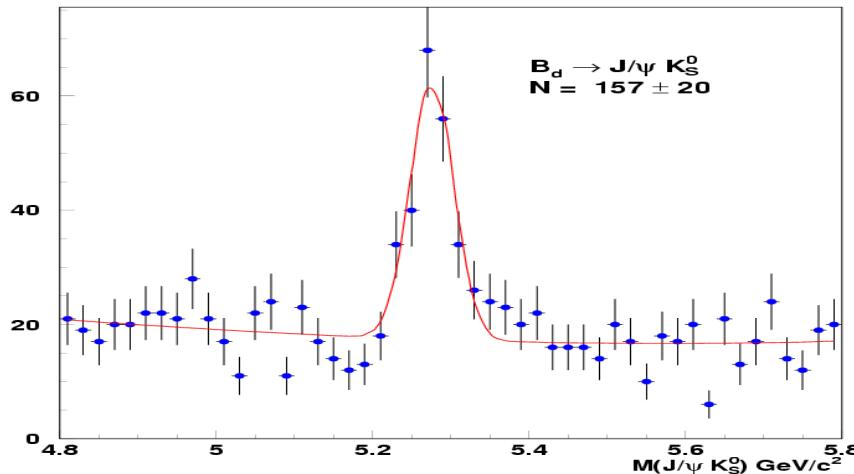
Do RunII Preliminary, Luminosity=114 pb⁻¹



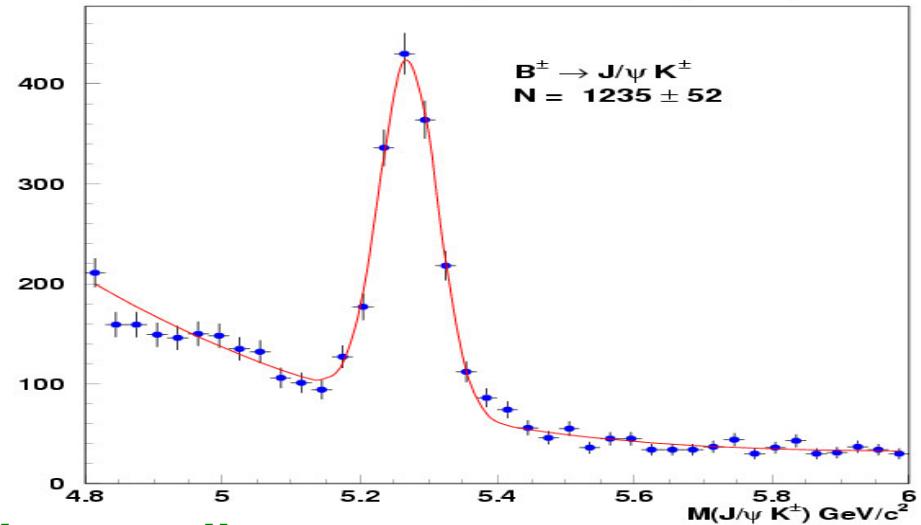
Do RunII Preliminary, Luminosity=114 pb⁻¹



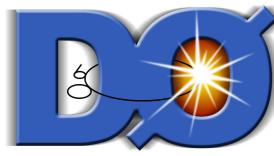
Do RunII Preliminary, Luminosity = 114 pb⁻¹



Do RunII Preliminary, Luminosity=114 pb⁻¹



For CP and Lifetime studies



B Lifetime Measurements



Predictions

- $\tau(B_d)/\tau(B_s) = 1 \pm 0.01$
- $\tau(\Xi_b^0) \approx \tau(\Lambda_b) < \tau(B_d) < \tau(\Xi_b^-) < \tau(\Omega_b)$
- $\Gamma(\Lambda_b) - \Gamma(\Xi_b^-) \approx 0.11 \pm 0.03 \text{ ps}^{-1}$
- $0.9 < \tau(\Lambda_b)/\tau(B_d) < 1$

*Report of the B Physics
at the Tevatron
Workshop (12/2001)*

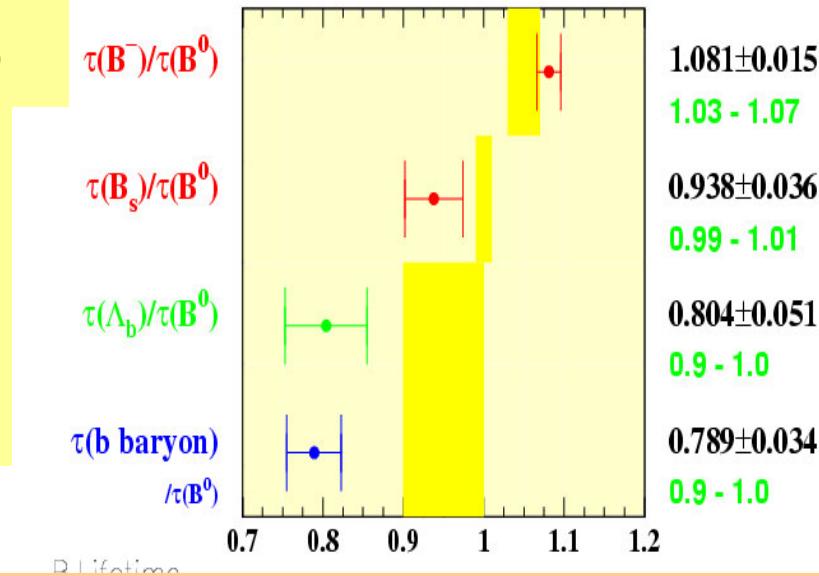
Experimental Results

- $\tau(B) = 1.573 \pm 0.008 \text{ ps}$
- $\tau(B^0) = 1.534 \pm 0.013 \text{ ps}$
- $\tau(B^+) = 1.652 \pm 0.014 \text{ ps}$
- $\tau(B^+)/\tau(B^0) = 1.081 \pm 0.015$

- $\tau(B_s) = 1.439 \pm 0.053 \text{ ps}$
- $\tau(b_{\text{baryon}}) = 1.210 \pm 0.051 \text{ ps}$
- $\tau(\Lambda_b) = 1.233^{+0.078}_{-0.076} \text{ ps}$

B Lifetime Group (Summer 2003)

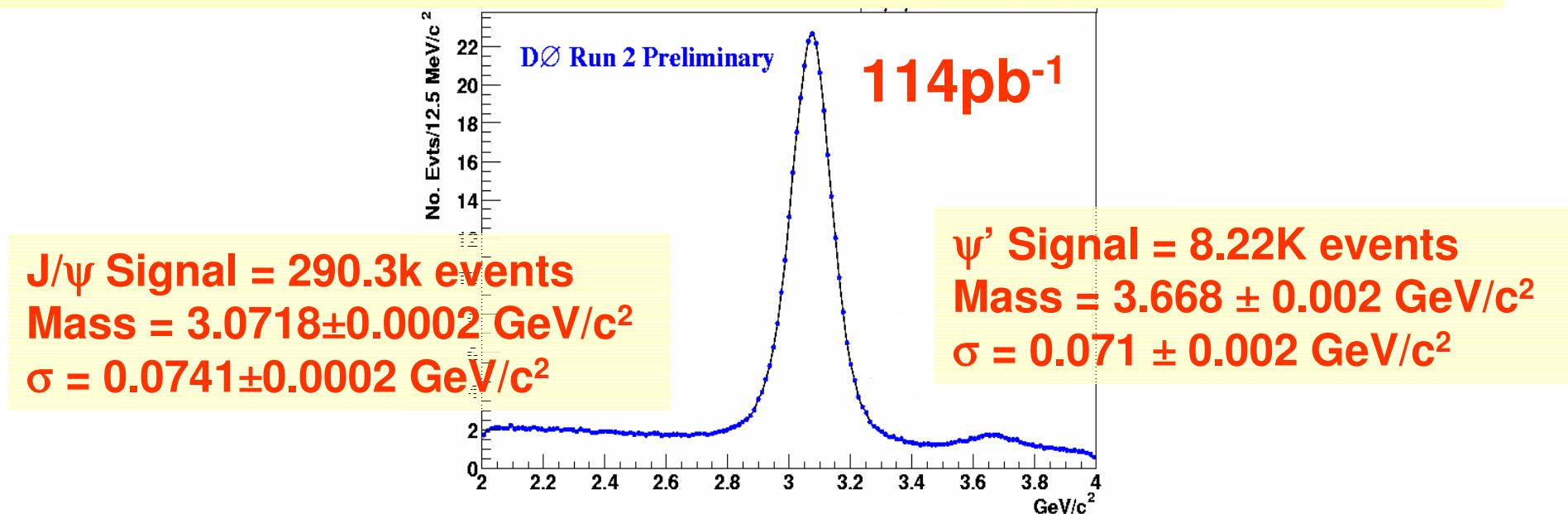
Comparisons

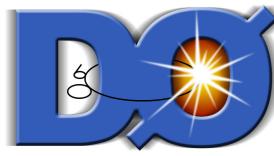


Measuring Lifetime using $B \rightarrow J/\psi X$, $J/\psi \rightarrow \mu^+\mu^-$

Use $J/\psi \rightarrow \mu^+\mu^-$ for tagging, vertex constraint, p_T determination:

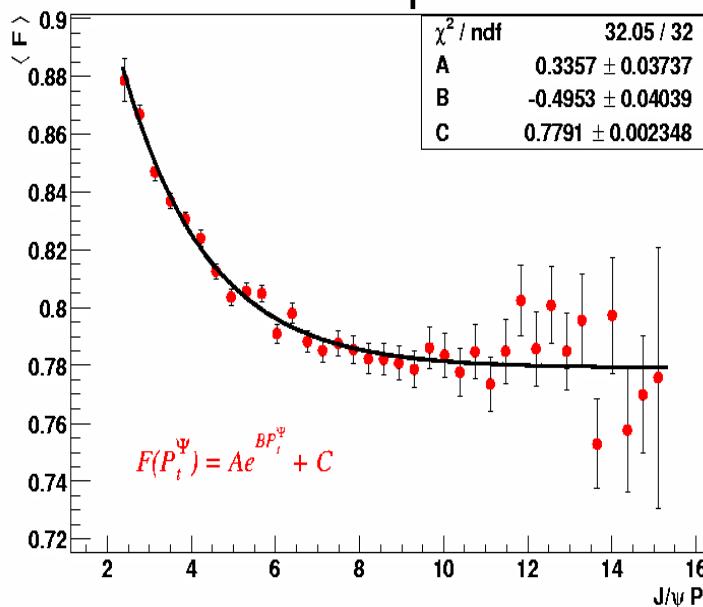
- ✓ Clean signal
- ✓ Large statistics
- ✓ Good vertex resolution
- ✓ Good momenta resolution
- ✗ Large prompt J/ψ contamination
- ✗ Need Pt correction factor from MC





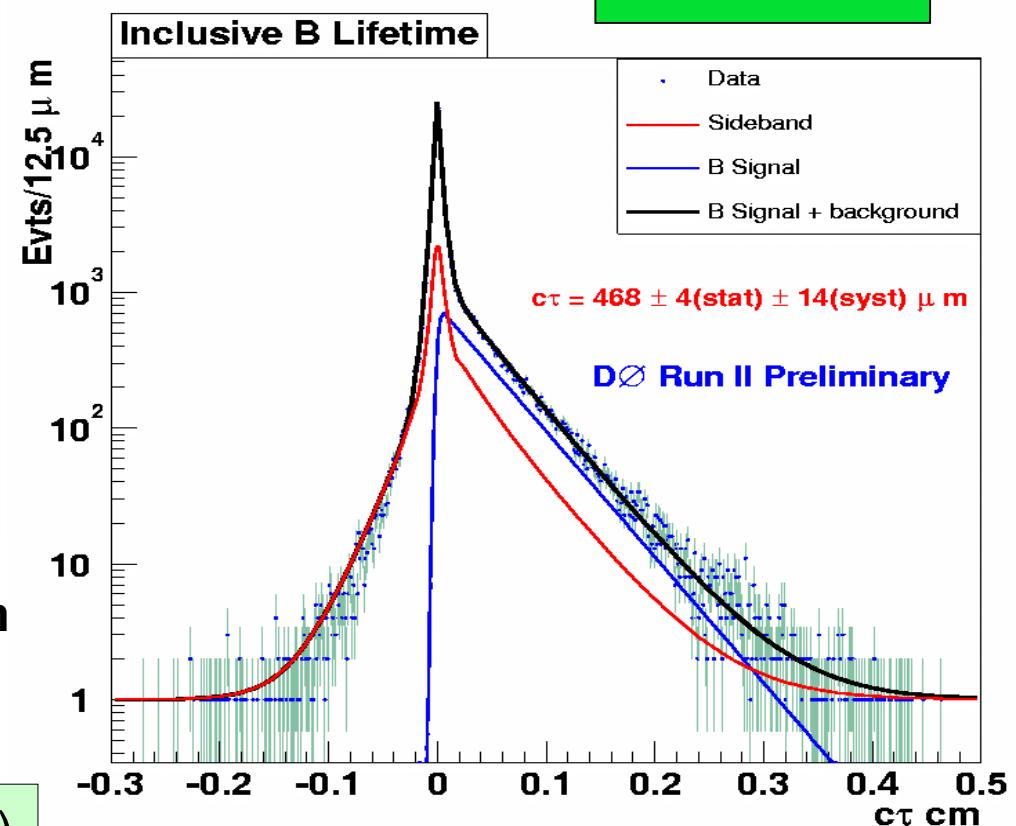
B Lifetime from Inclusive $B \rightarrow J/\psi + X$

$b \rightarrow J/\psi X$



$$\int \Sigma dt \approx 114 \text{ pb}^{-1}$$

$$\lambda = \frac{L_{xy} M_\Psi}{P_{\tau\Psi} F(P_T)}$$



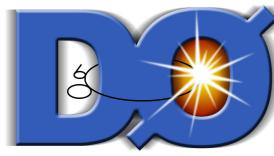
F: correction factor to use the pT(J/ψ) to estimate the momentum of the B to find proper time.
Obtained from Monte Carlo

$$\langle \tau \rangle = 1.564 \pm 0.014 \text{ ps (PDG)}$$

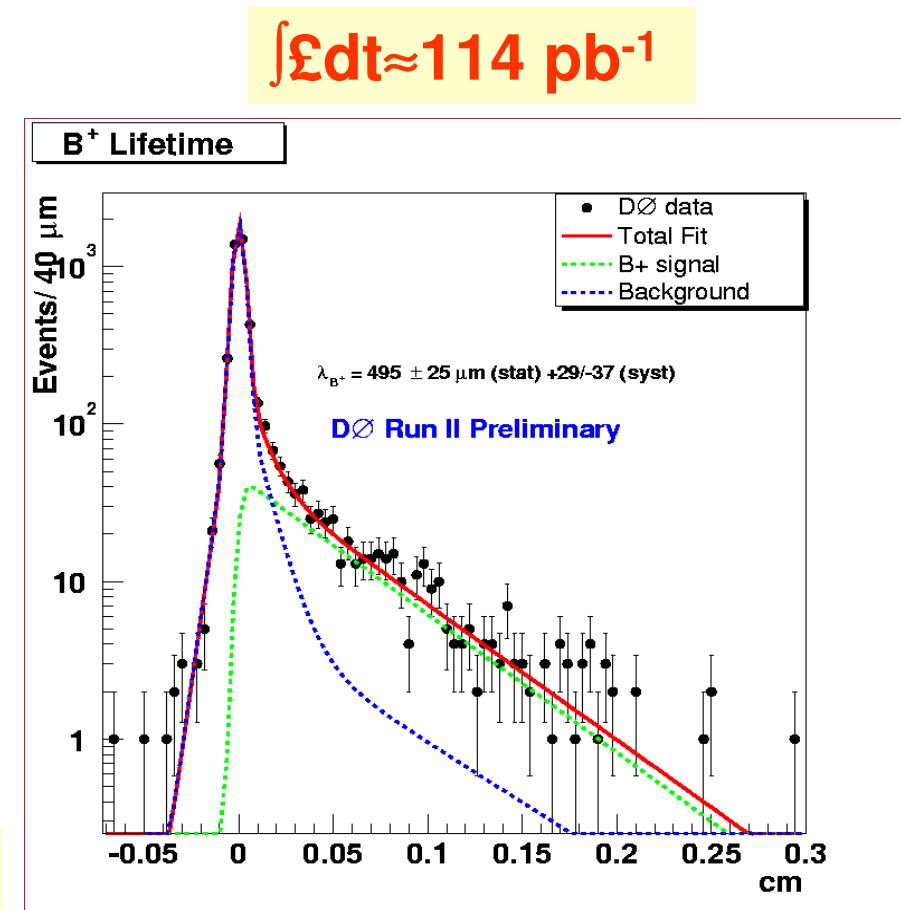
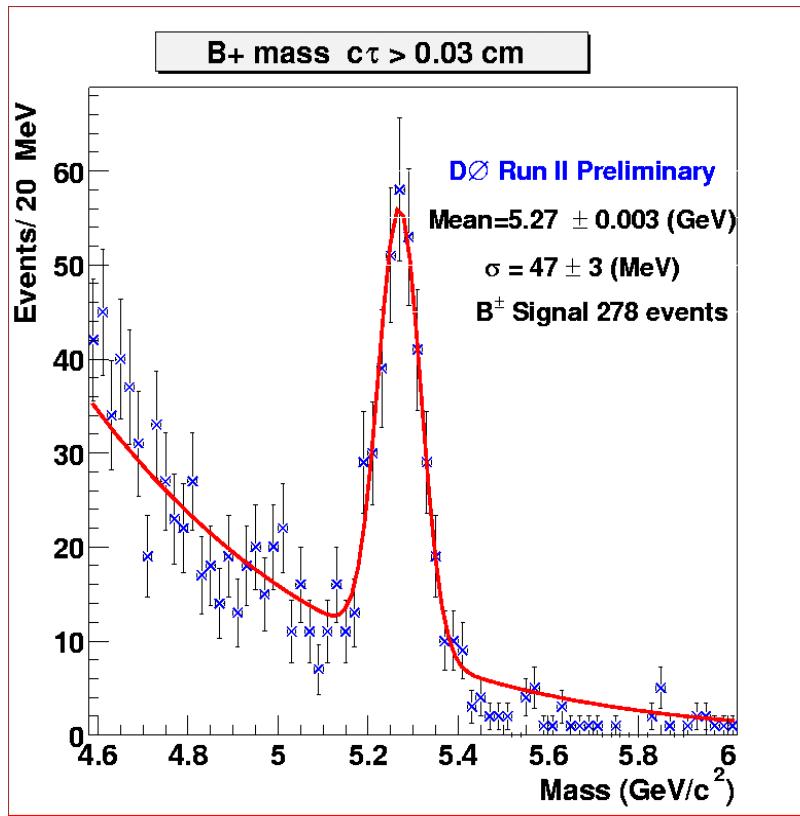
$$\langle \tau \rangle = 1.562 \pm 0.013 \pm 0.045 \text{ ps}$$

J/ψ from B's = 18%

Correction factor leads to the major systematic error



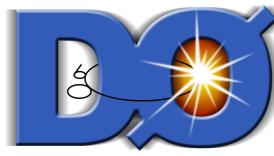
B^\pm Lifetime from $B^\pm \rightarrow J/\psi K^\pm$



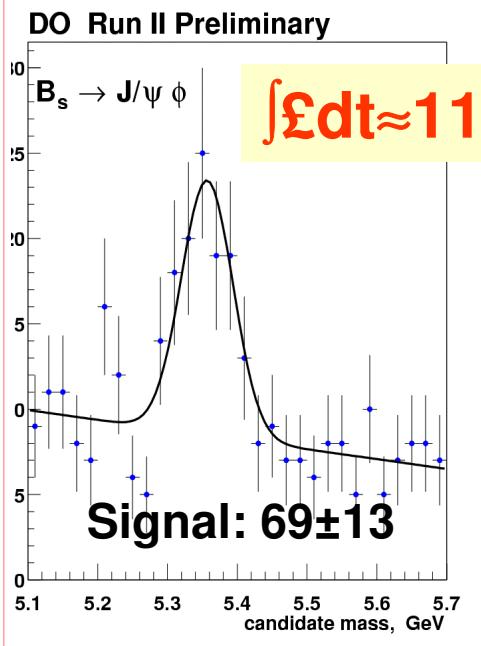
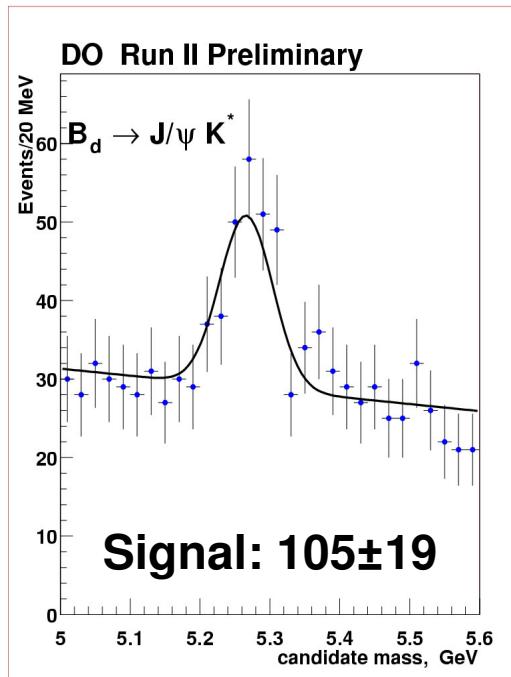
Fully reconstructed \rightarrow No Correction Factor!

$$\langle \tau_{B^\pm} \rangle = 1.65 \pm 0.083(\text{stat}) \pm 0.123(\text{syst}) \text{ ps}$$

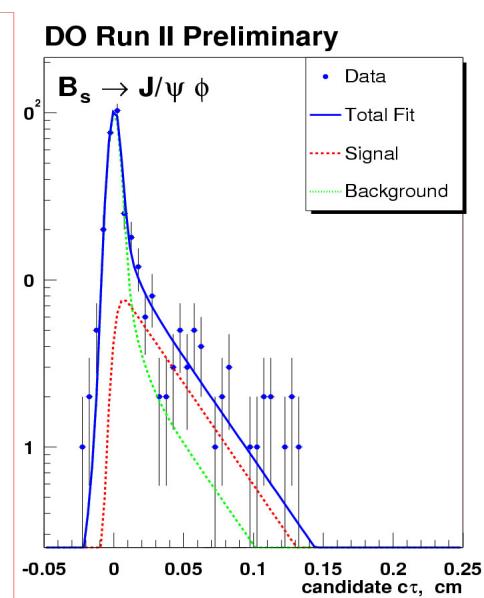
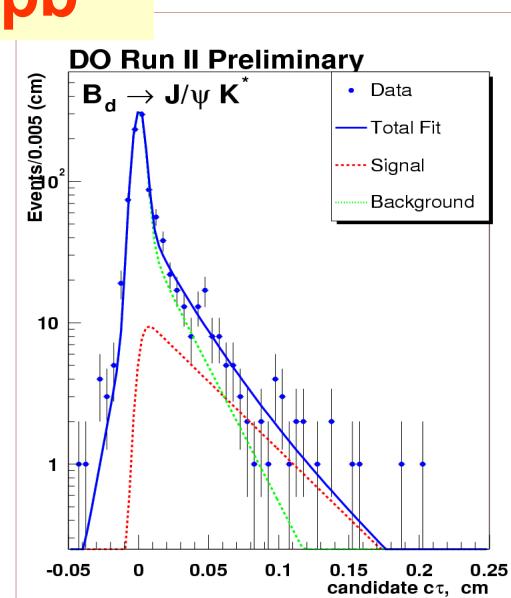
$$\langle \tau_{B^\pm} \rangle = 1.671 \pm 0.018 \text{ ps (PDG)}$$



$B_{d,s}$ Lifetimes from $B \rightarrow J/\psi + K^0, \phi$



Similar kinematics → Some systematic errors can be cancelled in ratio!



$$\tau_{Bd} = 1.51^{+0.19}_{-0.17} \text{ (stat)} \pm 0.20 \text{ (syst)} \text{ ps}$$

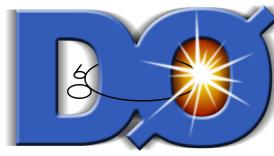
$$\tau_{Bs} = 1.19^{+0.19}_{-0.16} \text{ (stat)} \pm 0.14 \text{ (syst)} \text{ ps}$$

$$\tau_{Bs}/\tau_{Bd} = 0.79 \pm 0.14$$

$$\text{PDG: } \tau_{Bd} = 1.537 \pm 0.015 \text{ ps}$$

$$\text{PDG: } \tau_{Bs} = 1.461 \pm 0.057 \text{ ps}$$

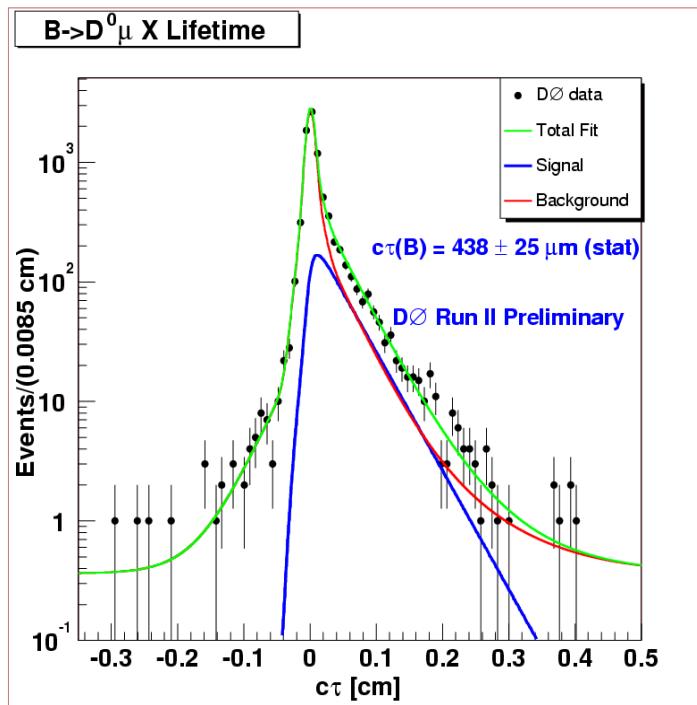
$$\text{PDG: } \tau_{Bs}/\tau_{Bd} = 0.95 \pm 0.038$$



B Lifetime from Semileptonic Decays $B \rightarrow D^0\mu X$

$\int L dt \approx 12 \text{ pb}^{-1}$

We are able to measure Lifetime



$$c\tau = L_{xy} M_b K / P t_{(D+\mu)}$$

$$K = P t_{(D+\mu)} / P t_B \text{ (from MC)}$$

$$\tau_B = 1.460 \pm 0.083 \text{ (stat) ps}$$

We will use this for mixing studies



Mixing: Flavour tagging

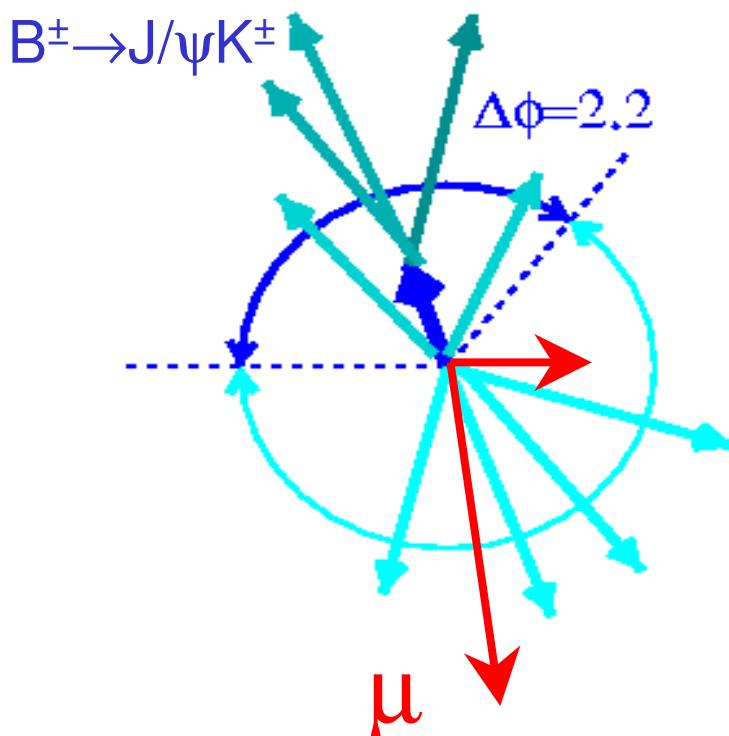
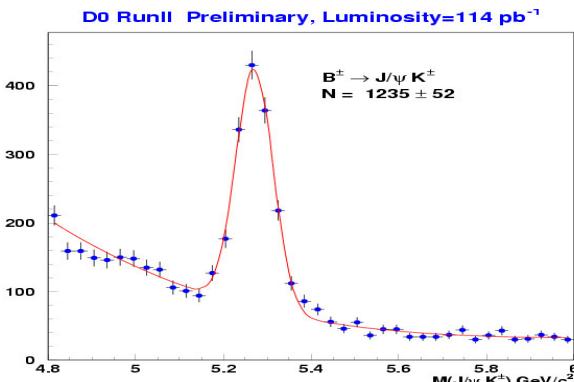
- Use **flavour-specific decays** to get flavour of B at decay. To get **flavour of B at production** use

- Soft-lepton tags - High dilution power, low efficiency (SL decay of other B)

$$D = \frac{N_R - N_W}{N_R + N_W} \quad \varepsilon = \frac{N_R + N_W}{N_R + N_W + N_{\text{notag}}}$$

- Jet Charge tag - Poorer dilution power, high efficiency (track-jet from other b quark)
 - Same Side tagging - Poorer dilution power, high efficiency (fragmentation, B^{**})
- We test this tools using B^+ data sample

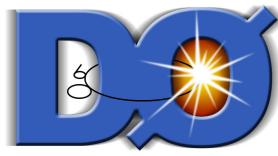
Opposite Side Muon Tagging



- $P_T^\mu > 1.9 \text{ GeV}$
- Q_μ – charge of muon with the highest P_T
- Classification:
 - $Q_\mu \neq Q_K$: correct tag
 - $Q_\mu == Q_K$: wrong tag
 - No muon : No tag

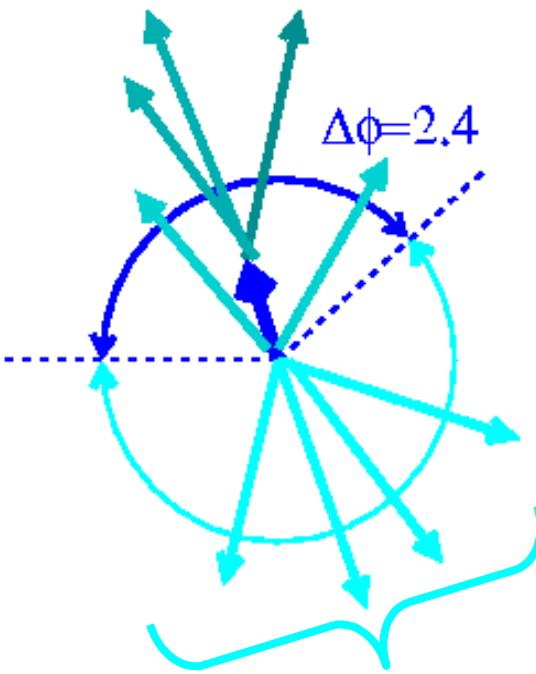
DØ RunII preliminary

- D = $(57.0 \pm 19.3)\%$
- $\varepsilon = (5.0 \pm 0.7)\%$
- $\varepsilon D^2 = (1.6 \pm 1.1)\%$



Opposite Side Jet Charge Tagging

$B^\pm \rightarrow J/\psi K^\pm$

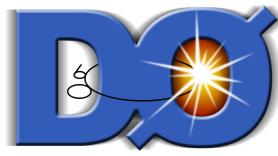


$$Q = \sum P_t q / \sum P_t$$

- $P_T > 0.5 \text{ GeV}$
- $\Delta Z_{PV} < 2 \text{ cm}$
- Classifications:
 - $|Q| > 0.2 \text{ } \&\& \text{ sign}(Q) \neq Q_K : \text{correct tag}$
 - $|Q| > 0.2 \text{ } \&\& \text{ sign}(Q) == Q_K : \text{wrong tag}$
 - $|Q| < 0.2 : \text{no tag}$

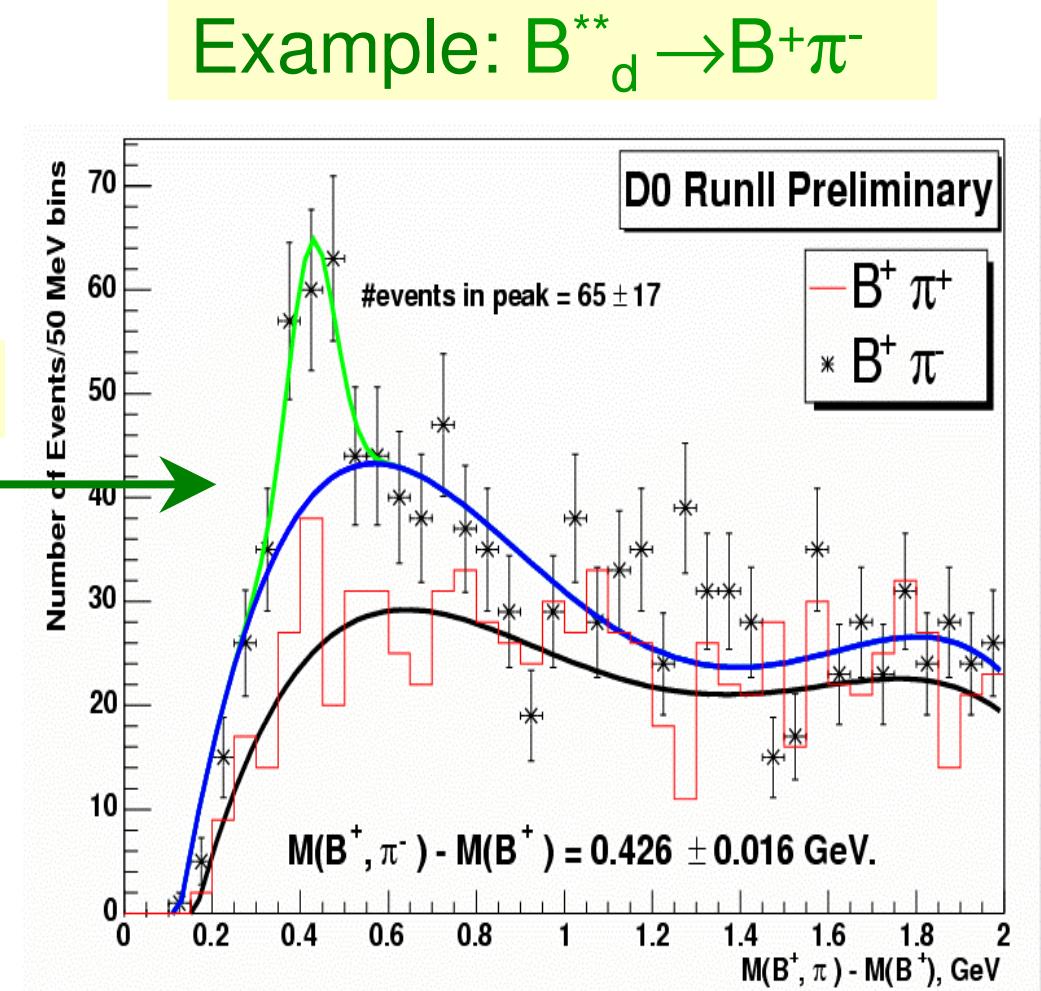
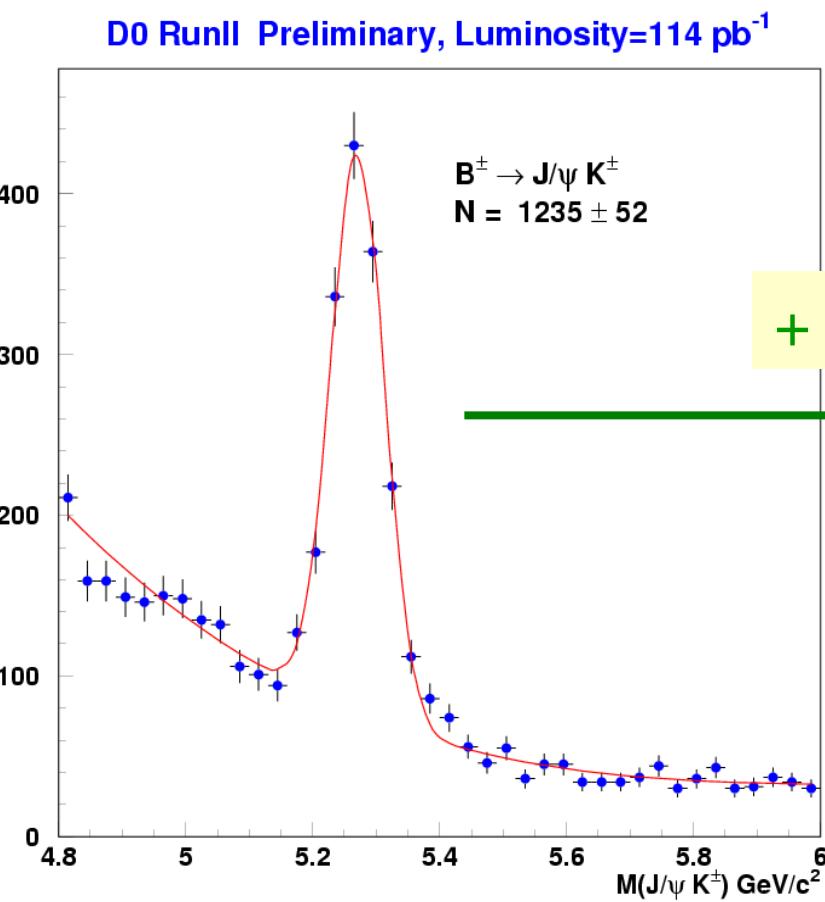
DØ RunII preliminary

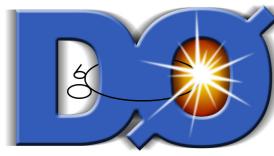
- $D = (26.7 \pm 6.8)\%$
- $\varepsilon = (46.7 \pm 2.7)\%$
- $\varepsilon D^2 = (3.3 \pm 1.7)\%$



Same Side Tagging

Excited B^{**} decays into B and pion/kaon that carries the initial state flavor information





Flavour Tagging results



DØ RunII Preliminary

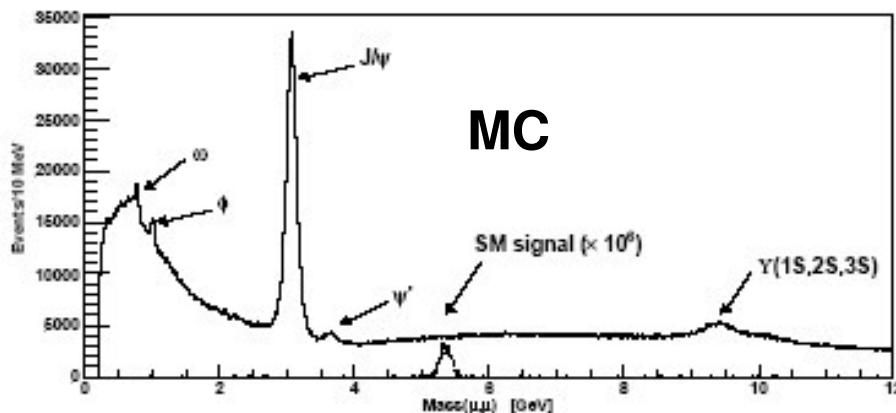
Method Based on B+ Signal	Efficiency ϵ	Dilution D	Tagging Power $\epsilon D^2 (\%)$
Soft Muon	5%	57%	1.6 ± 1.1
Jet Charge	47%	27%	3.3 ± 1.7
Same Side	79%	26%	5.5 ± 2.0

Muon DATA, will also use electrons

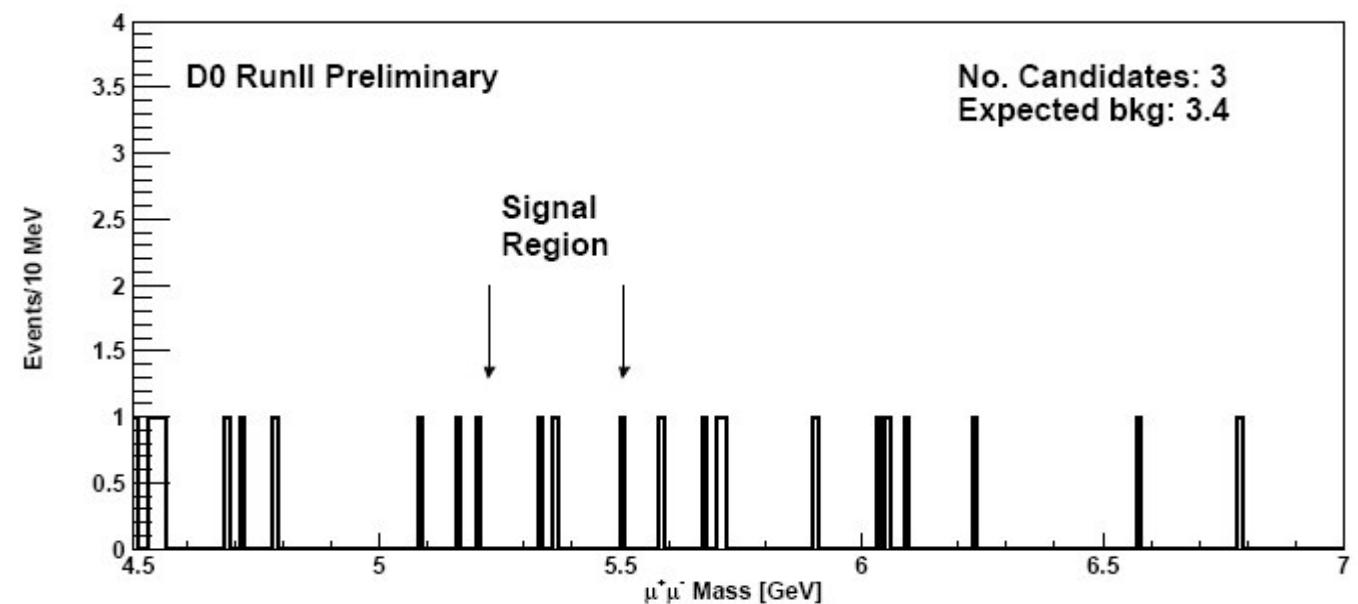
Performance with B^0/B_s is under study



Search for $B_s \rightarrow \mu^+\mu^-$



$\int L dt \approx 100 \text{ pb}^{-1}$



$\text{Br}(B_s \rightarrow \mu^+\mu^-) < 1.6 \times 10^{-6} \text{ at } 90\% \text{ CL}$

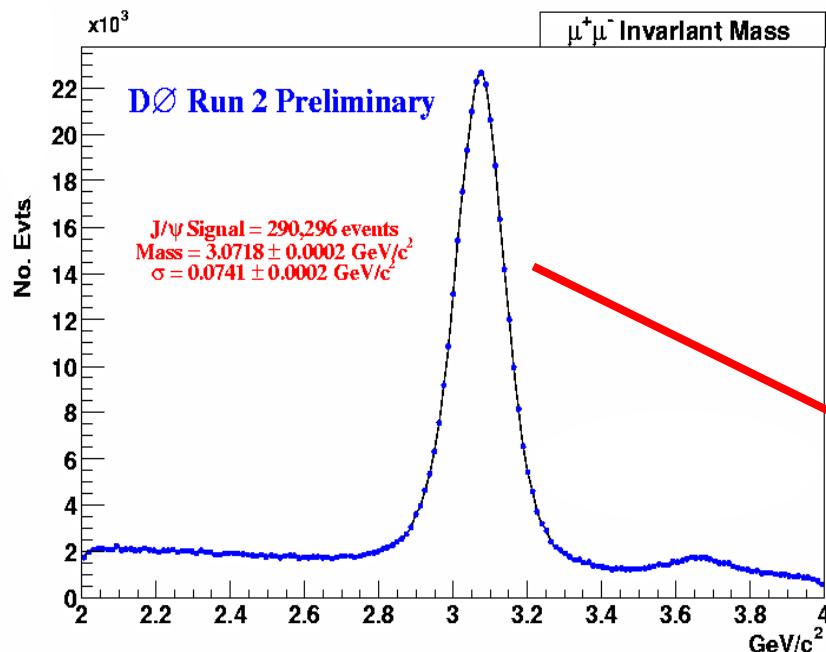


Summary

- DØ has observed the X(3872) particle in 200 pb⁻¹ data
 - Statistical significance of 4.4 σ
 - $\Delta M = 0.7684 \pm 0.0035$ (stat) ± 0.0039 (sys)
 - Data separated into various regions, we found similar behaviour as $\psi(2S)$, within statistical uncertainties
- Many other results as B physics program under way
- We have reprocessed ≈ 200 pb⁻¹ of data to better improve our analyses
- A lot more interesting results very soon!



More Data



Reprocessed $\int L dt \approx 200 \text{ pb}^{-1}$

